SOME FORMS OF NATURAL TRAINING TO WHICH CERTAIN BIRDS ARE SUBJECTED

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On pages 274 and 275 of an earlier article on instinct and habit,[1] I discussed some natural training methods to which certain climbing birds are frequently subjected and which give rise in the case of the cockatoo to particular forms of behavior which I there referred to as 'cockatoo-2- and cockatoo-3-rhythms.' The training methods served, as the table on page 275 of that article shows, not only to rhythmize responses of long duration, but also to permanently isolate from them unitary groups and rhythmized series of movements of particular numerical values. I shall now turn to other birds, especially the carnivorous ones, and attempt to explain certain interesting regularities in their behavior. The investigations which I shall soon present consisted primarily in studying carefully the ordinary behavior of the animals under normal conditions.

The raven (Corvultur albicollis, Lath.): This is a large bird from East Africa which I observed carefully for more than two years in the Zoological Garden at Berlin, Germany. This bird cleaned its beak, as birds often do, by striking first one side and then the other against various objects of its environment. It did this at almost all times of the day, but unusually often after it had eaten a meal. Unlike many birds, however, this one frequently cleaned one side of the beak more thoroughly than the other. If the biological purpose in wiping the beak is to clean it, the animal should be expected to clean both sides equally well, unless something interfered with the perfect fulfillment of this noble purpose. Because no artificial training was applied to this bilaterally symmetrical organism to cause it to perform an asymetrical act, one may hope to discover the influencing factor or factors only if one carefully observes the more fundamental life activities of the bird which are conditioned by certain stimuli and then modified by certain other environmental forces.

In the case of this bird, the original response of striking the beak has been broken up into a number of fragments or uni-

[1] Ueber einfache Bewegungsinstinkte und deren kuenstliche Beeinflussung, *ueit. f. Sinnesphysiol.*, 1915.

tary groups of movements which contain from a single one to twenty-one perceptible elements. The expression '3-g' in the table which follows, means that the bird struck first one side of the beak, then the other, and then the first side again before it became active in some new way. The order of the strokes might be right, left, right, or left, right, left. Those groups, the initial elements of which were strokes of the right side of the beak, are indicated in the table as 'Right-sided groups,' while the others are given in the next lower row of figures as 'Left-sided groups.' The row of figures after 'Totals' shows, without regard to the nature of the initial strokes, the totals of the various quantitatively different groups. Fifteen months were required to obtain the data of the following table.

Group-names.....	1-g	2-g	3-g	4-g	5-g	6-g	7-g	8-g	9-g	10-g	11-g	12-g	13-g
Right-sided groups....	4	7	50	20	52	22	55	21	28	11	8	40	1
Left-sided groups.....	12	27	380	66	396	290	471	55	183	173	45	120	36
Totals.....	16	34	430	86	448	312	526	76	211	184	53	160	37

	13-g	14-g	15-g	16-g	17-g	18-g	19-g	20-g	21-g
	1	21	14	4	2	1	0	0	1
	36	59	62	15	9	12	3	0	0
	37	80	76	19	11	13	3	0	1

It is easily observed from the table that the largest numbers of groups were those which the bird began by striking the left side of the beak. If this is a valid criterion for right- and left-sidedness, the figures show that the bird is decidedly left-sided. However, I could discern no clue to explain this fact. I was much interested to learn in this connection that other ravens of the same and other varieties which I observed were about as frequently right- as left-sided and that some were either-sided.

The bird's head gives immediately every indication of its prey. The most noticeable feature is its large, somewhat hooked beak which would seem to be well designed for tearing flesh. The truth is that this variety of the raven eats a large variety of things, such as fruit, grain, and flesh, but it is primarily a carnivorous scavenger. The birds of this variety frequently capture and devour small animals, but ordinarily they do not partiçipate in this if they have access to a carcass.

The ravens, as well as all other flesh-eating birds, should be looked upon as typical grasping animals; for the activity of tearing flesh is essentially a grasping activity which is normally modified at intervals by the extra exertions of biting harder and by pulling and tugging.

I observed that when this particular specimen tears flesh from a carcass, it first takes hold of a piece of flesh (the first

perceptible element of the activity), and then pulls back (the second element); if the piece does not come loose, the bird gives an unusually strong tug which results as a rule in a pronounced movement of the head to either the right or the left (the third element); and if this strong tug does not free the piece from the carcass, the bird frequently lets go to secure eventually a better hold. The flesh seldom comes loose when the bird merely pulls back; the most effective exertion is the tug to the right or to the left. The left-sidedness of the bird is here manifested by its tugging harder and also more frequently to the left, while grasping the piece of flesh.

This behavior might enable one to account for the preponderance in the table of the 3- over the 2-groups.

The following form of behavior manifested in tearing flesh might likewise enable one to account for the unusual frequency of occurrence of the 5-groups manifested in the decidedly different activity of cleaning the beak. Whenever this particular raven retains a good hold on the flesh after the first tug to the left, it tugs next to the right (the fourth element), but by no means as strongly as to the left; and this time, if the grasping activity is not completely interrupted, as when the piece is freed from the carcass or when it slips from the beak, the bird next tugs strongly to the right (the fifth element). This extra strong tug frequently frees the piece from either the carcass or the beak, thus causing the grasping activity to be interrupted completely. Essentially the same statements can be made concerning the 7-, 9-, 11-, 13-, and other odd groups.

We should now try to understand why the 6-, 10-, 12-, and 14-groups appear, relative to the even ones, so much more frequently. So far, I have considered only those cases in which the bird manages to grasp the flesh firmly until one or another of the unusually strong tugs is exerted, and have not considered what the succeeding group might be if the bird should lose its hold at any time and again grasp and tug at the piece without becoming active in a new way in the meantime. If the piece should slip from the beak at the third, fifth, or seventh movement, the bird might again grasp the flesh immediately and in each case repeat the previous group. One should observe in these cases the 6-, 9-, 10-, 12-, 14-, 15-, and other large groups which are multiples of 3, 5, and 7. Observations show that although it is generally the case, this bird does not the second time invariably lose its hold or secure a piece of flesh at numerically the same movement at which it previously secured one, or at which it lost the same piece the first time. However, the same group of movements, when

numerically considered, is often observed to recur when the bird is attempting to secure a piece which it is not able to free by any amount of pulling and tugging. The necessary conditions are here provided for repetitions of groups of the same number of elements. The investigation described in the two following paragraphs shows conclusively that when an object at which the bird tugs is kept entirely constant, the animal does perform a series of quantitatively identical groups in attempting to free the piece.

After a few trials, I succeeded in regulating a strip of rawhide so that when the raven seized the free end of it, there occurred first the backward pull, and then the strong tug to the left before the piece was released. Frequently, the bird did apparently the same thing over and over without pausing. The groups generally contained three elements, and only a very few times two or four. I later adjusted also a tendon from a horse's leg to call forth in the raven apparent repetitions of the 5- and 7-groups. These groups were numerically the same, since all of them contained the same number of elementary movements, but the serious question arises here as to whether or not the same nervous structures which condition the muscular responses of one of the groups also function to condition the movements of any other one of the groups which are quantitatively the same. A large number of investigations which I have conducted on other animal subjects, as well as on human beings, yielded data which justify the statements that the nervous correlates of the different quantitatively identical groups are not the same, and also, that the nervous structures which function and condition one elementary muscular movement of a group are not involved in the direct conditioning of any other element of the same group; I have been compelled to conclude that the nervous structures which function at one time and successfully condition one muscular movement of a group conditions at the same time action in other nervous structures which, in functioning, condition in turn a similar muscular movement which is another element of the muscular group. The simple fact that an extra activity can be associated with a particular elementary movement of a group so that it is regularly conditioned by this element and not by any other one of the same group, is conclusive evidence that the nervous structures differ in the cases of the different elements of the group. It is this circumstance which makes possible a rhythmical series, i. e., a series of movements in which accentuated movements occur at regular intervals. These accentuated movements are ordinary elements which are accompanied by extra responses that are

responsible for the greater expenditure of muscular energy manifested at these respective points.

I attempted to adjust the tendon and also the raw-hide to call forth in the raven the 4-, 6-, and 8-groups, but my attempts were astonishingly unsuccessful. Apparently, this was due to the circumstance that the fourth, sixth, and eighth tugs which the raven gave were much weaker than the third, fifth, seventh, and ninth ones; and apparently, this in turn was due to the fact that the bird was left-sided, or at least that it was not either-sided.

An either-sided raven (Cervus corax, L.): It seems appropriate to give here the groups of another carnivorous bird of a closely related variety, a specimen of the European Raven. This individual differs from the first animal in that it is smaller, that it is either-sided, and that its beak is almost straight instead of hooked. Because the beak is not as well constructed for holding onto flesh that is grasped, this bird, while tearing flesh, seldom makes groups of movements that contain more than two elementary movements. These are the seizing movement and then the strong pull. If the piece does not come loose from the carcass when the bird pulls, it usually escapes from the mouth, because the straight beak is not well adapted for holding the flesh securely. The movements of biting and pulling often occur alternately for a considerable time before the bird becomes active in some new way.— The data presented in the following table were obtained in the course of six weeks.

Group names.....	1-g	2-g	3-g	4-g	5-g	6-g	7-g	8-g	9-g	10-g	11-g	12-g	13-g
The groups.....	3	70	34	105	18	38	15	21	7	7	3	5	0

This bird manifested an unusually strong tendency to clean both sides of the beak equally well, as is shown by the high frequency fluctuations of the groups containing even numbers of elementary movements. Unless some activity of ordinary life, such as that of tearing flesh, has modified the activity of wiping the beak, these fluctuations should not be so high. I shall suppose that this is the case, and to support the supposition, I shall present some typical groups which can be gained by observing almost any of the insectivorous and herbiviorous birds. For this purpose, I shall use the data gained from a finch.

The finch (Cyanospiza lechlancheri, Lafr.): This bird is a native of Western Mexico. It, too, is either-sided. The groups in the following table were obtained in the course of six weeks.

Group names.....	1-g	2-g	3-g	4-g	5-g	6-g	7-g	8-g	9-g	10-g	11-g	12-g	13-g
The groups.....	12	32	59	54	41	33	17	10	10	3	0	1	1

In the results gained from this either-sided bird, no marked fluctuations with respect to the occurrence of either the odd or even groups appear; and there really seems to be no activity manifested in the ordinary life of the bird to cause such fluctuations as the records from either of the previously examined birds show. The finch can scarcely be called a grasping bird, because its grasping responses are generally of very short duration.

The goose eagle (Gyps fulvus, Gm.): To return to the typical grasping birds, another interesting case of apparent transferrence of ability — that is, the capacity of an animal to manifest with an apparently untrained bodily member or members the effects of the training of apparently only a single member — is manifested by the larger sized eagles. Many of the adults seldom walk or run symmetrically—they gallop, so to speak. For example, the goose eagle, a native of Southern Europe and South Africa, in walking or running, often throws the weight of the body more on one foot; and the same individual may at another time give the other foot the greater responsibility. This alternate accentuation of the elements of the walking or running activity is the act of performing the 2-rhythm; and the activity of tearing flesh is obviously responsible for the development of this rhythm.

The bird is very strong, and, accordingly, whenever it seizes a piece of flesh (the first element) and then pulls (the second element), the piece comes loose from the carcass, slips to the extreme end of the hooked beak, or escapes from it entirely. In any case, the grasping activity is interrupted at the particular point at which the grasping response of long duration is otherwise modified to some extent by the introduction by the bird of the second element, i. e., the strong pull. If the piece is freed from the carcass when the bird executes the strong pulling movement, it is swallowed — which means that the eagle, in swallowing, becomes active in a radically different way, and that a pause for the isolated fragment of the grasping activity is thereby produced — and if the piece slips to the extreme end of the beak or escapes from the mouth entirely, the eagle takes a new hold immediately, thus producing a second time the same number of movements. The alternate seizing and pulling, and accordingly the periodic accentuations and interruptions of the grasping activity, often occur many times before the flesh is secured.

In the cases of some of the eagles, the fourth or hind claw of one foot is so long that people often advance the theory that for this reason certain individuals do not run or walk symmetrically; but carefully made observations yield data

which show that this is an erroneous supposition. The presence of an extra long claw on a single foot of an either-sided eagle, i. e., of an eagle which gallops by throwing the bodily weight more on the one and then after a time more on the other foot, shows that the abnormally long claw is at least in some cases not responsible for the characteristic galloping behavior. Moreover, members of the smaller or weaker varieties of the eagle do not gallop. It is also interesting in this connection that certain carnivorous birds with relatively straight beaks, such specimens as our crow and buzzard, often gallop similarly as do the larger eagles. These are birds of appropriate sizes and also with appropriately shaped beaks that they necessarily make groups of movements in eating flesh which are generally the same quantitatively as those made by the stronger eagles with the hooked beaks.

General Discussion

Generally, a person who is acquainted with the more important life activities of an animal and also with the mechanism, as viewed externally, for manifesting the activities of interest, can predict with considerable certainty the quantitative values of the groups which any given bodily member will manifest. But one who attempts to make such predictions would do well to consider that if any unforseen exception or 'mistake' occurs in the performance of any of the groups of the modified responses, it is seldom an under-estimation, but generally an over-estimation most frequently by only a single element. This extra response is the one which was responsible for the isolation of the group from the response of longer duration, or, it is one which accidentally accompanied the inhibiting response. In either case, it accordingly became associated with the final element of the isolated group so that it is later conditioned by the final element and appears as a conclusion to the group in question. The extra response may or may not be similar qualitatively to the ordinary elements of the isolated group, as will be explained in the following paragraph.

It was always the case that whenever the ravens or the finch finished a group or rhythmized series, they became active in some new way. There is certainly nothing extraordinary about this simple fact; but it should be of considerable interest to us that groups of certain numerical values were frequently followed by very particular acts. One of the most interesting phenomena of this sort was manifested by the first raven. In approximately 40% of the cases, the bird bit and pulled the feathers of its breast for several seconds immediately after

the sixth element of the 6-group was executed. The bird did this also in conclusion to some of the other groups, but far less frequently than to the 6-group. For example, such an activity was the conclusion of the 5-group in approximately 2%, and of the 7-group in about 4% of the cases. The activity compound of wiping the beak six times and then biting and pulling the feathers of the breast, was not established under controlled conditions; but the circumstantial evidence in the case indicates that at some time or another the longer series of striking the beak was interrupted at or immediately after the sixth element by an itching of the breast which caused the new response. Perhaps the stimulus for the new response was a louse.

Sometimes, however, more troublesome movements of the head or of the body as a whole follow regularly, let us say the 4-group. Some of these are so simple quantitatively and so similar qualitatively to the ordinary elements of the group that even though the extra movement does not serve to cleanse the beak, an observer is nevertheless tempted to rank this movement with the elements of the 4-group and accordingly speak of a 5-group. This would be, however, a pure 4- and only a pseudo-5-group.